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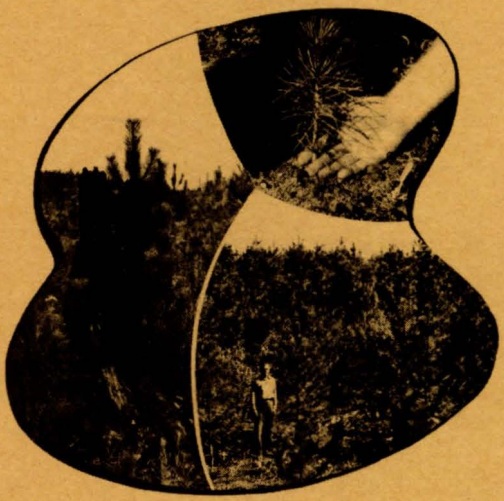
FOREST TREE PLANTING IN THE INLAND EMPIRE



by

Donald W. Lynch

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UNITED STATES DEPARTMENT OF AGRICULTURE
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NORTHERN ROCKY MOUNTAIN FOREST
AND RANGE EXPERIMENT STATION

MISCL. PUB. NO. 5

JULY 1952

NORTHERN ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

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Prepared in the Division of Forest Management Research

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FOREST TREE PLANTING IN THE INLAND EMPIRE

By

Donald W. Lynch
Division of Forest Management Research

INTRODUCTION

PLANTING NEEDS

Good management of most forest land requires an active planting program. On areas where natural regeneration cannot be obtained in a reasonable time or is entirely precluded because of no seed supply, trees must be planted to establish a new stand. Planting is needed most urgently during the early phases of a forest management program, because fires and severe cutting have generally depleted the growing stock. Direct seeding offers a second alternative for artificially reforesting denuded lands, but adverse climatic conditions, competing vegetation, and seed-eating rodents greatly limit the success of seeding. Planting nursery-grown stock is a more practical method of rehabilitating most of the deforested land in our region.

In the six counties of northeastern Washington alone, the Forest Survey (5) shows over 600,000 acres of poorly stocked and deforested commercial forest land, much of which should be planted to bring it to full timber production. Private ownerships, a large number in small woodlots, account for two-thirds of the land in the poorly stocked and deforested category. To encourage forest planting by private owners, state nurseries sell planting stock at less than cost[1/].

1/ Within the region to which this report applies, state forest nurseries are operated by the Department of Forestry and Range Management, Washington State College; Forestry School, University of Idaho; and Forestry School, Montana State University. These nurseries receive contributions from state sources and federal grants-in-aid under Section 4, Clark-McNary Act to produce planting stock for reforestation and shelterbelt purposes.

LOCAL PLANTING PROBLEMS

Much of the land in need of planting in the Inland Empire is of rather poor site quality. The better sites which are accessible have in many cases been converted to agricultural use. Good sites which cannot be farmed because of rough terrain, rockiness, or inaccessibility are often covered with dense brush or less desirable tree species.

Two main problems are evident: The first is that of establishing trees on poor sites where, because of light soils or southerly and westerly aspects, the moisture supply may be critically low during the growing season. Pine forests flourished on many such sites in the past, but to establish a new stand by planting without the protection of existing trees and often on depleted soil requires special effort and skill. The second problem is that of eliminating or reducing competing vegetation on the more productive areas until the planted trees become established.

This pamphlet summarizes planting information applicable to eastern Washington, north Idaho, and western Montana. Its purpose is to present the best existing information in simple style rather than to report on new research. Undoubtedly, further research in planting and site preparation methods would result in developing more economical procedures to use on the many different situations that exist in this region.

Ponderosa pine planting techniques receive the greatest emphasis because this species is commercially one of our better species and is widely distributed and well adapted to growth on much of the lower-elevation and more accessible forest land in smaller private timber holdings. Of course, many places can be found where different kinds of trees should be planted. In most respects the planting techniques recommended for ponderosa pine also apply to other species.

Nursery practices are covered briefly to point out some essential requirements of good planting stock.

NURSERY PRACTICE

SEED SOURCE

Increased attention must be devoted to seed collecting. Seed for planting stock should be collected from trees growing on habitats very similar to those which are to be planted (4). Within a single tree species, many different strains, each adapted to a particular environment, have developed over the centuries. Site factors such as length of the growing season, precipitation, temperature, exposure, and soil quality produce or indirectly account for strain characteristics which apparently are hereditary.

In addition to choosing proper geographical location for seed collections, individual trees superior in form, vigor, and growth rate, should be selected when opportunities permit. The common practice of collecting cones from squirrel caches obviously prevents any individual tree selection and in some cases results in collecting immature cones. Whenever possible, cones should be taken directly from the tree, not only to insure proper parentage but also to get properly matured cones.

CLASS AND CHARACTER OF STOCK

Ponderosa pine planting stock ranging from 2-0 seedlings to 2-2 transplants have been successfully planted on a variety of sites. Repeated observations show, however, that the older and larger stock survives better on critical sites. If trees are to be successfully planted on poor soil with severe exposures, low precipitation, or excessive competition from other vegetation, large robust transplants, which are within the size limits imposed by the planting method, should be used.

On the easier planting sites such as newly cut-over and burned land on north slopes where moisture supply is good, 2-0 seedlings have given good results. Seedling stock, of course, costs less to grow than transplants. Drill sowing with root pruning promises to produce satisfactory planting stock comparable to transplants and will be less expensive than transplanting. Drill sowing at different row densities is currently being tested at the Washington State College pine nursery.

Considerable variation naturally occurs within a given class of nursery stock. Careful culling and sorting are therefore essential in selecting planting stock for severe sites. Trees should be chosen which are of large size, good form, and good color, and which have large stems and low top-root ratio. Smaller and poorer stock can be reserved for planting on better sites.

Care is required in lifting and handling nursery trees to prevent mechanical injuries and root desiccation. The bark on fine roots slips easily and is often damaged in the lifting process. Drying of fine roots, even for a short period, may seriously damage coniferous trees.

Storing trees at temperatures above 40° F. can cause breaking of dormancy which is often fatal to planting stock which must undergo prolonged storage, or it can sometimes cause molding which may seriously lower vitality. Nurseries are usually well equipped for storage, but damage from high temperatures sometimes occurs to trees after they leave the nursery.

Recently obtained evidence indicates that shingle tow used as a packing material may have a toxic effect on seedlings[2/]. Damage to the trees apparently increases with length of time that the roots are in contact with the material; packing trees in shingle tow for periods of two weeks or longer should be avoided, according to the results of these studies. However, the U. S. Forest Service nursery at Savenac, Montana, has packed nursery stock in shingle tow for many years and neither their specific experiments nor general experience has revealed any harmful effects from this low-cost, easily obtained, and good moisture-holding material. Sphagnum moss, if available, makes an ideal medium for packing.

Covering tree shoots with a protective coating such as lanolin to reduce transpiration water loss has promise of yielding significantly better survival on dry sites. The process has been used successfully in the Southeast with longleaf pine (1), and it is currently being tested in this region by the Washington State College.

2/ Tarrant, R. F.; Isaac, Leo A.; Mowat, E. L.; and Engstrom, W. A. Progress report on Deschutes 1950 tests of ponderosa pine field planting. Pacific Northwest Forest and Range Experiment Station. Unpublished report, typewritten. 1951.

PLANTING PREPARATIONS

SELECTING AREAS TO PLANT

The best sites should be planted first. Planting is an expensive process, and the investment should be directed to areas that promise good survival as well as rapid tree growth. The best sites, of course, are often covered with shrubs and inferior tree species if deforestation occurred considerably earlier. Where a choice is possible, select areas that are relatively free from competing vegetation, but some kind of site preparation will often be necessary. Recent burns are usually the easiest areas to plant.

Following is a list of conditions to avoid in selecting a planting site. If necessary, trees can be successfully planted on such areas, but special techniques are required.

1. Steep hillsides where the soil is loose and unstable.

2. Badly eroded areas.

3. Severe exposures - southerly and westerly slopes where no shade is available.

4. Coarse, gravelly soil.

5. Areas occupied by heavy brush or less desirable tree species unless site preparation is planned.

If there is any possibility of securing natural reproduction of desirable species within a reasonable time, planting generally should be deferred.

Plantation protection for the first few years should be considered in selecting an area. Grazing by domestic stock or wildlife may seriously damage a plantation during its early life. Avoid places where domestic stock congregate or deer concentrate in the winter unless they can be excluded by fencing. Adequate fire protection is essential.

Once a planting area has been chosen, a map should be prepared from a simple survey to establish the acreage and to map in small areas which should not be planted because of existing natural reproduction, unfavorable soil, or for other reasons. The map will also serve well in planning the actual planting procedure.

SITE PREPARATION

Successful plantation survival and growth often depend upon proper site preparation. Conditions such as a heavy brush cover, dense grass or sod, logging slash and debris, or merely dry sites with poor soil and hot, dry exposures require advanced treatment to prepare them for planting. Site preparation measures usually are expensive. However, a realistic appraisal will show that the expense often is necessary and in the long run justified. Without the extra work and expense, perhaps planting should not be attempted.

Following are some of the more important methods of site preparation which have been used in this and other regions:

Burning. As mentioned above, recent burns are about the only areas that do not require some type of preplanting treatment. Prescribed burning is an inexpensive and effective site treatment on areas where it can be used safely. Its use is limited, of course, by fuel types in which it is effective and by the risks involved in the use of fire. Burning is employed most commonly and with good success on logged-off land where slash and debris are hazards to planting. Prescribed burning in conjunction with lethal hormone sprays (2,4-D and 2,4,5-T) has good possibilities for reducing the hazards of brush fields (3). Lethal hormones have been used in two general ways: (1) Spraying after burning to kill sprouts on areas where brush and other fuels were adequate to support a good burn and (2) spraying before burning to kill brush and improve burning conditions on areas that would not burn well in the green state. Burning without spraying does not effectively eliminate shrub growth because of the vigorous sprouting following the fire.

Dozer clearing. Clearing brush in strips with bull-dozers prepares a good seedbed but is expensive (9). The Olympic plow, mounted in place of a dozer blade, has been used for clearing strips in tall brush and saplings.

Furrowing. Various types of plows have been used with good success for brush clearing and furrowing. The large Killifer, Baldwin, Mesaba and Wagler plows, used by the Forest Service in various regions, produce furrows 18 inches wide or wider and are able to cope with dense brush or sapling growth on level or comparatively level ground. On steeper slopes they are naturally less efficient. Furrows should be deep enough to remove sod and surface roots, but no deeper. They should lie open about two months in advance of planting; or in the case of spring planting, furrows should be made the fall before in order to permit them to stabilize. Trees planted in fresh furrows are sometimes covered by falling soil.

Furrowing is extremely helpful even though competing vegetation is no problem. Planting is easier and hence is apt to be better. The added protection and better moisture supply also improve seedling survival. Running furrows east and west affords some protection from the sun, and furrowing on the contour helps hold moisture and prevents erosion.

Disking. Disking greatly improves plantability. In the Lake States, disking twice with an Athens disk, the second time at right angles to the first, proved, in some cases, to give better survival and height growth in red pine plantations than furrowing did (8). Disking effectively reduces competition of brush and grass and improves the soil by mixing the fertile topsoil with the lower layers. It costs only slightly more than furrowing and can be used on areas where stumps, rocks, and heavy roots preclude furrowing.

Scalping. Clearing away brush and sod with a hand mattock to make a spot for a planted tree has proved to be very expensive and generally less effective than mechanical site preparation. Scalping is not recommended (11).

CARE OF PLANTING STOCK

Extreme care and attention to details are required in handling planting stock from the time it leaves the nursery until it is planted. Planting stock is perishable. The roots must be kept moist at all times. Drying kills the finer rootlets and no amount of moisture added later will restore them. Roots damaged by drying and later moistened may appear normal; the ill effects may not show up until the tree dies in the plantation.

Temperature should be controlled. Molds are more likely to develop on the roots and tops of bundled or closely packed trees at temperatures above 40° F. Furthermore, at higher temperatures, the tops transpire faster and demand more water replenishment from the roots. Trees subjected to temperatures above 40° F. for any length of time will break dormancy and begin to grow, a process which at first is not visible. Keeping trees continuously dormant is desirable during prolonged storage. During spring planting season, trees that are to be planted within a few days will not be injured if growth begins and does not advance too far.

In order to hold both moisture and temperature at desirable levels, certain precautions in the handling of stock must be observed.

Transportation of planting stock. Planting stock is transported most commonly by truck from the nursery to the planting site, although rail express has been used successfully. Regardless of the method, speed and care are required because the environment during transit is usually unfavorable. If a covered truck is not available, trees must be covered with a tarp to prevent drying. They must be ventilated beneath the canvas if the truck is stopped for any length of time because heat from the sun which goes through the cover will warm the air excessively unless ventilation is provided. It is highly desirable to transport trees at night, if possible, because of the more favorable temperatures and humidity. On a long haul, trees need watering.

Heeling in. Upon arrival at the planting site, trees must be heeled in immediately unless they are to be planted within two or three days. The process is described below (6, 11):

1. At the planting camp or other place convenient to the job, select a level area in the shade or part shade, if possible, where the soil is easily dug and well drained, and a water supply is at hand.

2. Dig a trench about a foot wide and a foot deep, with one side sloping at a 60° angle and as long as needed.

3. Open the crates, bales, or boxes of trees, remove the packing, and wet the roots.

4. If the trees are tied in bundles, do not cut the string unless the bundles are very large, or the trees are to be left heeled-in over ten days. Place the trees in a thin layer along the sloping side of the trench, with their normal ground line just below the level of the ground. Place a 2- or 3-inch layer of dirt on the roots by digging from the opposite side of the trench and pack firmly. Repeat the process until there are six or eight layers in one trench, then fill the trench with soil and pack down firmly so that drying air is excluded from the roots. Avoid covering the tops, because conifers are easily injured by dirt on the needles.

5. If the soil is dry, wet it thoroughly at once and every day or two thereafter as needed. Avoid excessive watering which may cause the ground to become soggy.

6. Different species or lots should be kept in separate blocks, and the oldest lots used first.

7. If the heeled-in trees are not in the shade and they are to be left several days, erect over them a framework at least two feet high covered with brush or boughs. Do not cover with a tarp because that shuts off ventilation but not heat.

Not more than 6 or 8 days' supply of trees should be held in the heel-in beds unless the weather is very cool. A smaller inventory would be better. Plan transportation so that new supplies from the nursery come in regularly.

Cold storage. Nurseries are usually well equipped for storing stock for long periods if lifting and planting schedules do not coincide. Storage temperatures, as stated above, must be 40° F. or lower, but freezing temperatures should be avoided. If for any reason it becomes necessary to store planting stock in the field for any length of time before planting, some type of refrigeration must be provided, especially if the planting date is to be beyond the time when growth usually starts in that area. Snow pit storage, described by Olson (7), has proved satisfactory for extended storage in the field.

PLANTING

PLANTING SEASON

Fall and early spring are both suitable planting season in our region. In the fall, planting must be delayed until the soil has been well soaked by rain; in the spring, of course, the snow must be gone. Local conditions will generally govern whether planting is best done in the spring or in the fall, although there are distinct advantages and disadvantages to each season.

Spring planting generally gives better results because root growth is ready to start and the water demands of transpiration are quickly supplied. However, in years when serious dry spells occur in the spring, newly planted trees suffer from drought before their root systems can become established. Unless local conditions such as inaccessibility in the spring, high elevations, or administrative reasons require fall planting, spring planting usually is preferred.

Fall planted trees must be thoroughly "hardened" in the nursery before lifting, or they cannot withstand the new environment. The short period of root activity between planting time and winter sometimes prevents establishment and results in high mortality from winter drying or winter killing unless trees are well covered with snow. Fall planted trees are also sometimes injured by snow breakage and frost heaving.

HAND PLANTING

Crew organization. The size of the crew needed to complete the project within the brief planting period obviously is governed by the acreage to plant, the number of trees to be planted per acre, and the man-day production expected. The planting method used considerably affects the number of trees that a man can plant per day. (See planting methods.)

The most efficient planting organization consists of squads of ten to fifteen men for each foreman. Large crews with more than one squad usually require a planting superintendent in addition to the foreman. On small projects, the planting squad might be as small as two to five men, in which case the foreman could plant along with the men in addition to supervising and inspecting. Crews should be made up, if possible, of high-class laborers who have an interest in the project. Planting trees requires conscientious devotion to detail as well as a good, strong back!

Foremen should be experienced planters. They have the responsibility of training and continuously checking the performance of the men under them. They should inspect calibre of planting periodically by actually digging up trees to see if the roots are straight and well packed. Considerable training time must be given to new men before they start planting. Foremen also have the responsibility for the care of the planting stock and tools.

The project superintendent, if the organization is sufficiently large to require one, inspects the quality of the planting, keeps records and maps up-to-date, assigns planting areas to the foremen, runs the camp, if any, and arranges transportation for men and equipment.

The planting squad. A squad, consisting of from ten to fifteen men, should be lined up with the men spaced at the desired distance between rows, and proceed across the planting area as a unit. The lead man, who should be the best planter in the squad, follows a flagged line and sets the pace for the squad. Each succeeding man maintains the proper distance and stays slightly behind the planter on his lead side. An experienced planter should also be placed on the far end of the squad. The last man has the added job of flagging the line with white paper or cloth on stumps or bushes to mark the course for the return trip. The foreman assists in keeping the line well marked.

When the strip across the area has been completed, the squad moves over as a unit and reverses its direction, with the guide man following the new flagged line. Each planter remains in the same numerical order from the guide man as before. In steep country it is better to proceed up and down the slope rather than on the contour, and if the ground is very steep, it is sometimes better to walk back to the bottom of the hill and plant only on the uphill trip.

Tools and equipment. The following tools and equipment are needed for each squad:

1. One Northern Region one-hand planting mattock or an ordinary two-hand grub hoe for each man. The special planting mattock has a straight blade $2\frac{1}{2}$ inches wide and at least 8 inches long. Grub hoes are similarly shaped but larger.

2. One canvas water-proof planting bag or a planting box for each man. Planting bags preferably should have two compartments - a small one for trees ready to plant and a large one for a half-day supply of trees.

3. Water bags or canteens, either individual ones to be carried by each man or large ones to be left at the end of the strips. Water is needed for drinking purposes as well as to moisten the trees.

4. For the foreman, a compass, map, notebook, belt axe, tally register, cloth or paper for flags, and a measuring pole to check spacing.

Care in planting. Planting the tree is the final and most important phase of the entire program. It requires skill and care, yet at the same time speed in order to keep the cost of planting at a minimum (2).

Several different planting methods have been successfully used in various parts of the country and for various species, but the one commonly accepted by the Forest Service in this region is the one-man mattock slit method by which an experienced man can plant 800 trees or more per 8-hour day.

Severe sites, however, require improved planting technique. Slower, more careful planting, using a method that gives better root spread and closer contact with the soil, is necessary to obtain good survival on poor sites. Naturally, the more detailed methods are slower and costs are correspondingly higher.

Regardless of the method, it is only as good as the planter who uses it. Only by constant care and checking will the calibre of work be kept at a high level. Detailed descriptions of two different methods of planting are given below, and others are described by Rudolf (8). The following preliminary steps apply to all hand planting methods (6, 11).

1. Each planter will be given a supply of trees by the foreman.

2. One bundle of trees should be opened, the trees separated, and put in the small compartment of the planting bag with a good supply of wet moss or other packing material. The unopened bundles should be put in the large compartment and well packed and moistened. Planting boxes do not have separate compartments but handling of the trees should be similar in other respects.

3. The packing material must be kept well moistened throughout the day.

4. The foreman will make arrangements to replenish the trees throughout the day, either by storing a supply near the planting site or arranging for trees to be delivered during the day.

5. The trees in the planting bag should be kept covered and handled carefully to prevent roots from drying.

6. As each individual tree is removed from the bag to plant, care must be taken to prevent injury to the roots which are often entangled in the roots of the other trees.

The Northern Region one-hand mattock slit method. After the squad is lined up and ready to go, plant the trees according to the seven steps listed below and illustrated in figure 1.

Step 1. Quickly clear away any litter, loose rocks, or dry soil with a sweep of the mattock blade. Sink the mattock blade into the ground perpendicularly, its full length, if possible, in one stroke. This is best accomplished with a throwing motion. Completely release the handle near the end of the throw. If extra force is required to sink the blade its full length, press on top of blade with the left hand while working the handle back and forth with the right hand. Do not pump up and down on the handle.

Step 2. Raise up on the handle to open hole at bottom.

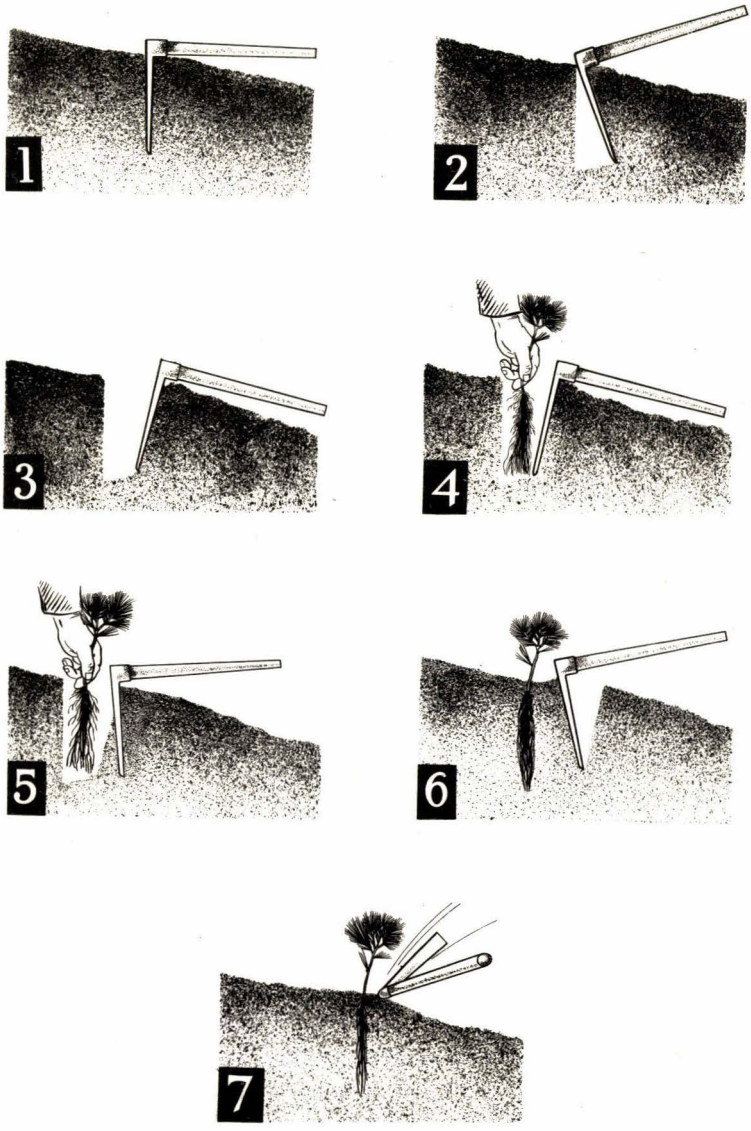

Figure 1. The mattock slit method of tree planting: (1) sinking mattock, (2) opening bottom of hole, (3) opening top of hole, (4) inserting tree, (5) closing bottom of hole, (6) closing top of hole, and (7) tamping.

Step 3. Forcibly draw the handle back horizontally to widen the slit into a square vertical hole.

Step 4. Keeping blade of mattock in hole (to hold back the soil) insert a tree vertically. Roots should be spread in the hole as naturally as possible, not twisted or allowed to hang together like a rope.

Step 5. Still holding the tree with its root collar even with the ground line, partly pull out the blade and by reinserting it at an angle and giving a downward and forward thrust, press a wedge-shaped mass of soil against the lower roots to fill the bottom of the hole.

Step 6. Remove the blade and with one or two additional downward and forward thrusts with the mattock, push the hole full of soil. These thrusts should seat the roots firmly!

Step 7. Before moving to the next spot, lightly tamp the soil around the tree with the back of the mattock; only one stroke on each side. If tamping causes a depression, scrape a little soil with mattock or shoe to fill up hole. At the same time, it is often convenient to mulch around the tree with litter or loose soil.

The center-hole method. Well suited for use with large stock and on all soil types, the center-hole method gives good results. It affords an opportunity to get the tree roots straight, well distributed, and in close contact with the soil. Its main disadvantage is slowness; only about 300 trees can be planted per man-day. It is recommended for use (a) with extra large stock, (b) on rocky or hard soils where the slit method is not effective, (c) with inexperienced workers or young boys who cannot handle the one-hand planting mattock, and (d) for small planting operations if lowest cost is not regarded as highly important. A grub-hoe should be used in place of the smaller one-hand planting mattock. Following are the detailed steps of the method (8):

Step 1. Quickly clear away any litter, loose rocks, or dry soil with a stroke or two of the grub-hoe blade. Sink the blade perpendicularly to its full depth in such a way that the handle is nearly flush with the ground.

Step 2. Lift up and pull back and slightly to the right on the handle, depositing the soil near the right-rear edge of the hole.

Step 3. Repeat steps 1 and 2 if it is necessary to enlarge the hole or to take out roots or rocks. One or two strokes and not more than four should be sufficient to make a hole 8 to 12 inches deep and 6 to 8 inches wide.

Step 4. At the completion of the last stroke, drop the tool to the right of the hole with the handle toward the rear and drop to the right knee.

Step 5. With the thumb and forefinger of the left hand, take a tree from the planting bag, using the right hand to hold the remaining trees in the bag.

Step 6. Grasping the tree just above the root collar, hold it in the center of the hole so that the root collar will come just below the soil level and spread the roots with the right hand.

Step 7. With the right hand, scoop in a few handfuls of soil (avoid leaves and trash) and place it quickly and carefully about the roots in the bottom of the hole.

Step 8. Tamp the soil gently from three to five times with the fist.

Step 9. Scoop in more soil to fill the hole.

Step 10. Holding lightly to the top of the stem or needles, come to a semi-erect position, place both feet on the filled soil, and pack it firmly about the roots. Kick some litter or loose soil around the tree for a mulch.

If grub hoes are not available, shovels or spades may be used.

Some important requirements of good planting for any method are:

1. Keep the tree roots moist at all times.

2. Make the hole deep and wide enough to accommodate the roots easily with no doubling back of the root tips.

3. Set the tree at the same depth as it was in the nursery or slightly lower.

4. Be sure that the tree and the roots are perpendicular.

5. Fill the bottom of the hole as well as the top with moist soil and pack it firmly.

6. Prevent rocks, dry soil, rotten wood, and leaves from falling back into the hole against the roots.

7. Avoid "K" shaped holes which often cause poor root spread and an air space in the bottom of the hole. Figure 2 illustrates common mistakes in planting.

Spacing of trees. The standard Forest Service spacing for ponderosa pine in this region is $7\frac{1}{2}$ x $7\frac{1}{2}$ feet, which requires 800 trees per acre. However, on poor sites where more careful planting is expected and where a portion of the area is unsuited to planting, as few as 250 trees planted on carefully selected spots might be as effective as planting more. Often fill-in planting is needed to stock open patches in a stand of natural reproduction. Local conditions will govern the number of trees to plant.

Following are the number of trees per acre at various spacing:

Distance Between Trees	Number of Trees Per Acre
4' x 4'	2720
5' x 5'	1750
6' x 6'	1200
$6\frac{1}{2}$' x $6\frac{1}{2}$'	1000
7' x 7'	880
8' x 8'	680
9' x 9'	540
10' x 10'	430
11' x 11'	360
12' x 12'	300
13' x 13'	250
15' x 15'	200
20' x 20'	100

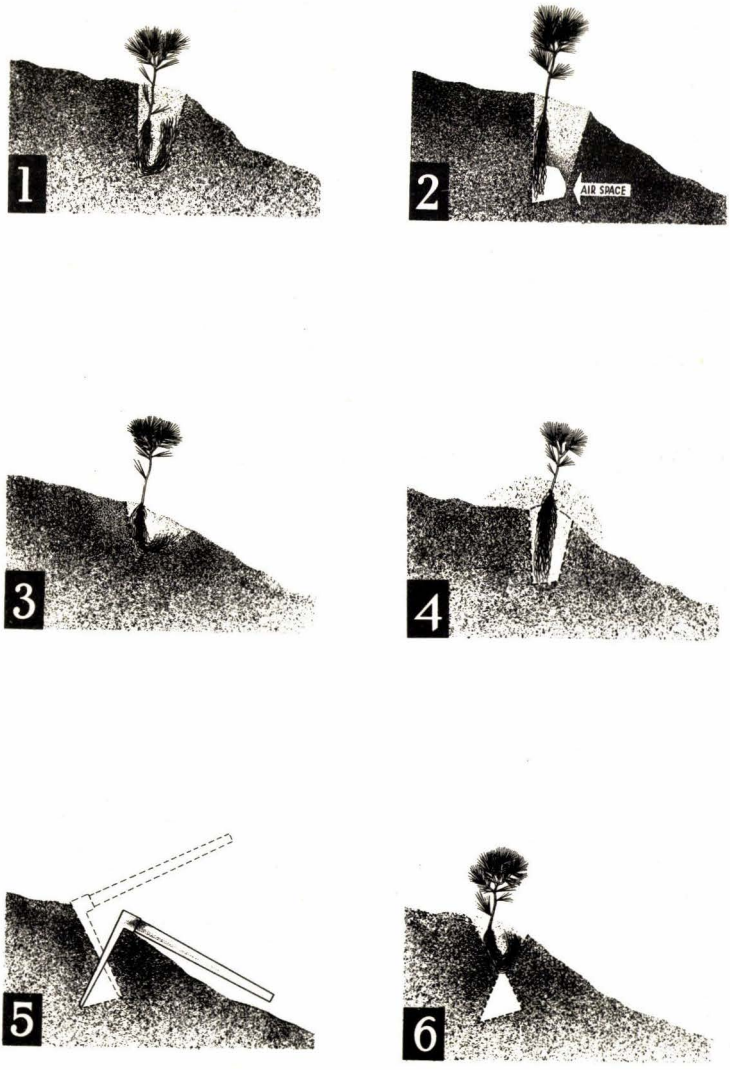

Figure 2. Common mistakes in planting: (1) tree too deep, roots turned up; (2) soil poorly tamped at bottom of hole; (3) hole too shallow, roots turned up; (4) hole too shallow, soil mounded to cover roots; (5) and (6) tree improperly planted because of "K"-shaped hole.

It is important with any spacing to allow considerable latitude in selecting the planting spot. Specific points to consider in selecting a spot are:

1. Choose good soil. Avoid spots that are rocky or where the soil has been burned red by an extra hot fire.

2. Choose the north side of logs, stumps, bushes, etc. where the planted trees will be shaded.

3. Avoid spots where sliding soil is apt to cover the tree.

4. Avoid mounds that might dry and depressions that might fill.

5. Avoid rotten wood.

6. Avoid spots with dense vegetation.

7. Avoid game trails or rodent colonies.

8. In furrowing plantings, place the trees on the south edge of the furrows to take advantage of shading. Planting at the edge of a furrow also gives some protection from stock trampling.

MACHINE PLANTING

Improved models of planting machines now give excellent performance under a variety of soil and vegetative conditions. Machine planted trees survive well and an average of 10,000 trees planted per day with a single machine is not unusual. Many different manufacturers are producing planting machines that vary considerably in size, cost, and performance. Some machines have been used successfully on slopes up to 30 percent. Where furrowing is desired, some models are equipped to plow the furrow along with the planting operation.

Although machine planting is new in this region, it should not be overlooked. Despite our generally rough topography, many of our planting sites are suitable for machine operation. Wherever the soil and topography permit, their use is highly recommended.

PLANTATION CARE

Responsibility for a plantation does not end when the trees have been set in the ground. The new crop needs protection from browsing by domestic livestock and wildlife and, of course, protection from fire. Sometimes the young trees need protection from rabbits, mice, and gophers. Furthermore, the planted trees may require various measures to protect them from drought, excessive heat from the sun, and excessive competition from other vegetation. Following are some recommended measures for various conditions:

Shading. Shading the newly planted trees with brush limbs, shingles, or other material insures better survival on hot, exposed sites (10). Because of the cost of shading, it is not generally feasible.

Mulching. Mulching around the newly planted tree with litter, straw, or even loose soil helps retain moisture.

Hoeing or cultivating. Hoeing or otherwise cultivating around the planted trees helps in reducing competition from other vegetation and improving the growth of the trees. It is recommended only where good survival and growth is more important to the owner than the extra cost.

Cleaning. If shrubs or other tree species overtop trees in a plantation, cleaning or cutting out the competing plants will usually allow the planted trees to gain in height sufficiently to hold their own in subsequent years. Aerial spraying of lethal hormones has promise of being an effective and inexpensive method of releasing plantations from brush competition.

COSTS

Planting costs vary from year to year and from one locality to another. It is impossible to list specific costs for the various phases of planting, but the following tabulation of costs for nursery stock, site preparation, and planting shows the ranges in a general way.

Item	Cost per acre Low	High
Nursery stock (800 per acre)	$5.00	$15.00
Site preparation	5.00	20.00
Planting	15.00	25.00
Total	$25.00	$60.00

Nursery stock varies in price by species and by age and class of trees. Seedlings are, of course, less expensive to produce than transplants. Local labor rates, cost of seed, capacity of nursery, and general nursery efficiency influence the cost of producing planting stock. The selling price at state-operated nurseries is likely to be between $7 and $15 per 1000 trees.

Site preparation expenses are influenced a great deal not only by the method used but also by the character of the ground cover, the soil type, the abundance of rocks, stumps, and other obstructions, and topography. Furrowing costs from $5 to $15 per acre while disking probably would cost about $10 to $20 per acre.

Prescribed burning expenses vary more widely than other costs because of the diverse fuel conditions, sizes of burns, and pre-burning preparations needed. In the white pine type where extremely heavy fuels are encountered and where extensive snag falling and line constructing are required, it costs about 1.3 man-days per acre[3/]. Prescribed burning in other timber types usually costs less.

Limited information on the expense of aerial spraying of brush fields indicates a figure of about $5 per acre (3).

Actual planting costs can be estimated to some extent from local labor rates. Figuring 800 trees per acre, a good planter can plant, under favorable conditions, about an acre per day. After overhead expenses have been added, planting costs, on this basis, would average between $15 and $25 per acre.

3/ Information from the Timber Management Office, U. S. Forest Service, Northern Region.

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